

Concept of defibrillation vector in the management of high defibrillation threshold

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Abstract

We present a case where defibrillation threshold was dangerously elevated to the point that the patient had no safety margin, and his implantable cardioverter-defibrillator generator was discovered to have migrated. Generator migration reduces the distance between the can and the coil, effectively creating a smaller bipolar current and sparing the left ventricle from the current needed for defibrillation. This case underscores the importance of securing the generator in place, as this patient would have been spared multiple shocks and an invasive medical procedure had his generator been better secured.

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Key words: Ventricular tachycardia; Defibrillation thresh-

old; Implantable cardioverter-defibrillator; Pacemaker

Core tip: Defibrillation threshold can be altered by a myriad of factors including generator migration. We report a case to illustrate the concept of implantable cardioverter-defibrillator defibrillation vectors and its effect on defibrillation threshold.

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INTRODUCTION

Defibrillation threshold (DFT) is routinely performed at the time of implantable cardioverter-defibrillator (ICD) implantation, but can be altered by a myriad of factors: lead placement, medications, sympathetic tone, electrolyte alterations, and shock vectors^[1,2]. "High DFT" is defined as an absolute shock value of > 25 J or a safety margin of < 10 J below the maximum device output. Elevated DFTs put the patient at heightened risk for sudden cardiac death due to inadequate defibrillation. Reports from the literature demonstrate the incidence of high DFTs between 2% and 24%^[3]; however, two large studies agree on a rate of 6.2%^[4,5]. Recommended approaches to the patient with high DFTs vary in the medical literature. Following options are recommended: reverse the shock polarity, change the shock configuration (e.g., tip-to-generator, ring-to-generator, tip-to-coil), modify the waveform, exchange the generator to a high-output device, discontinue medications that increase DFT if possible, add a superior vena cava coil, add a subcutaneous array, or move the generator to the left pectoral region if it is located on the right^[6]. Some ICD brands allow

reprogramming of the shock configuration even within a single treatment window, which theoretically increases the chance of successful defibrillation. Data suggests that a configuration where the right ventricular (RV) lead is the anode results in the highest success of defibrillation, but a small population of patients benefits from the reverse configuration^[3].

CASE REPORT

Eighty years old Caucasian male presented to device clinic for management of sustained monomorphic ventricular tachycardia (VT) leading to multiple ICD shocks. Medical history included coronary artery disease status post 3 vessel coronary artery bypass grafting in the remote past and severe ischemic cardiomyopathy with ejection fraction of 10%. Attempts were made to ablate his VT, but he continued to have episodes of appropriate ICD therapies. He had a bi-ventricular ICD (Bi-V ICD) with a lower rate of 80 beats per minute. Patient has had multiple hospitalizations in the past for appropriate ICD therapies.

Medical management of VT of the patient was complicated. He was previously managed on amiodarone, but this was stopped when his DFT became prohibitively high and obliterated the 10-joule safety margin. He was then managed with maximum dose of long acting metoprolol and did well until he started having appropriate shocks for recurrent VT. He was finally started on mexiletine, which he tolerated. One week after initiation of mexiletine he underwent repeat DFT testing. Multiple configurations and device outputs were tried unsuccessfully: 25 and 35 J from can and coil to tip; 25 and 35 J from tip to can and coil; 25 J from can to tip and tip to can. The patient was finally successfully defibrillated with 35 J from can to tip, again demonstrating a loss of safety margin.

His most recent cardiovascular work-up, including left heart catheterization, echocardiogram, and electrocardiogram showed stable, severe coronary artery disease and systolic dysfunction. A recent chest X-ray (Figure 1) shows his device in the left chest with a right atrial lead, a RV ICD lead, and a left ventricular pacing lead in the coronary sinus. He reported New York Heart Association class II symptoms, but was in good spirits. After careful review of the case, decision was made to place a right sided endocardial lead to the RV true apex which would then be tunneled to the left side. Attempts to place a pace-sensing lead from the left side at the time of ICD generator change had failed due to too many leads on the left side. If repositioning of the RV lead fails, placement of a subcutaneous array was planned. In the operating room, the device pocket was opened and it was noted that the generator had migrated substantially inferiorly across the chest wall. At this time, the generator was moved up to the subclavicular position and DFTs were retested. He was successfully defibrillated with 25 J, twice. A post-operative chest X-ray shows higher positioning of

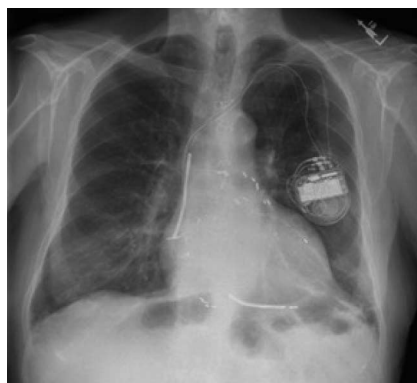


Figure 1 Chest X-ray demonstrating bi-ventricular implantable cardioverter defibrillator.



Figure 2 Note the changed position of the implantable cardioverter defibrillator Generator.

the ICD can in the subclavian position (Figure 2). He was discharged home the next day safely.

DISCUSSION

This case elegantly illustrates the concept of ICD defibrillation vectors. When the patient arrived, his DFTs were dangerously elevated to the point that he had no safety margin, and his ICD generator was discovered to have migrated. At the time of his procedure, the generator was nearly lateral to the left heart border. This malpositioning altered the electric field in that it allowed current to move anteriorly from the coil to the can, reducing the involvement of the posteriorly positioned left ventricle. Additionally, it reduced the distance between the can and the coil, effectively creating a smaller bipolar current and sparing the left ventricle from the current needed for defibrillation. This case underscores the importance of securing the generator in place, as this patient would have been spared multiple shocks and an invasive medical procedure had his generator been better secured. Even the newer, entirely subcutaneous ICD systems are reliant on proper positioning. In a recent article describing the initial Dutch experience with the device, three patients received inappropriate shocks due to lead migration. This complication was solved by adding an additional suture

sleeve^[7].

It is suggested that the RV lead be positioned to the true ventricular apex^[1]. More proximal positioning of the lead results in higher DFTs, but if the RV lead is positioned closer to the interventricular septum or RV out-flow tract, DFTs are improved^[3]. A recent study reported similar rates of high DFTs in patients with RV apical leads (3/108) *vs* RV septal leads (3/107)^[8]. The Septal Positioning of Ventricular ICD electrodes trial is currently underway and should help to answer the question of optimal RV lead position. It is important to consider that as ICD systems adopt the dual coil single lead configuration it will become more difficult to manipulate positioning to optimize DFTs.

With repositioning of his ICD generator, we were able to restore his DFTs to a safe level by correcting the malpositioning and optimizing the shock vector. To our knowledge, this is the only such case reported in the medical literature.

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